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VOL. XL, NO. 4 APRIL, 1946 WHOLE NO. 353

THE FIGURE OF THE EARTH

BY A. H. MILLER

I

APART from the diversification produced by hills and valleys the surface of the earth presents to the eye the appearance of a flat disc or very nearly that of a flat disc. Certainly it does not appear to be rounded like a ball. It has been claimed that mere observation suggests precisely the opposite. As is well known the effect of atmospheric refraction is to 'lift' the horizon, or to elevate distant objects above their true position. Viewed from an open place the horizon should therefore appear to rise above the observer who would thus acquire the impression of being situated in the depression of a slightly curved bowl. The expression 'high seas' for the open sea is said to refer to this phenomenon. The ancient Greek philosophers, highly trained in mathematics, taught us that the earth is approximately a sphere of such dimensions, that mountains and valleys represent only comparatively insignificant deviations from the simple ideal form.

The sphericity of the earth was asserted by Pythagoras about 540 B.C. Two hundred years later Aristotle thought it worth while to refute the arguments against the idea and to present those in its favour. He used arguments similar to those employed to-day, namely, the gradual disappearance of a ship beyond the horizon, hull first, then masts and rigging; the circular shadow cast on the moon during an eclipse; and the alteration in the appearance of the heavens in travelling from place to place. The spherical form was not, however, generally accepted until explorers had sailed around the earth,

although this is in itself less conclusive proof than any of those just mentioned.

Mathematicians of Aristotle's time appear to have considerably overestimated the size of the earth. Eratosthenes, librarian at Alexandria and a man of great learning, determined, in 250 B.C., the circumference of the earth by observation of the zenith distance of the sun at Alexandria, at noon on the day of the summer solstice. He was informed that on that day a well at Syene was lighted up throughout its entire depth, showing it was on or very nearly on the tropic of Cancer. He assumed Syene to be due south of Alexandria and adopted 5,000 stadia for the distance between the two places He observed the zenith distance of the sun, at Alexandria to be one ñftieth of the circumference of a circle (7 1/5 degrees) and thus obtained 50 times 5,000 stadia or 250,000 stadia for the circumference of the earth.

Although the modern equivalent of the unit of length employed by Eratosthenes is uncertain, the result obtained by him seems as reasonably in agreement with the true value as might be expected. The method is of particular interest because it remained standard practise for determination of the size of the earth until the close of the sixteenth century.

The Greek geographer, Strabo, who wrote at the beginning of the Chrisitan era and the Graeco-Egyptian astronomer Claudius Ptolemy who lived in the second century both give 180,000 stadia for the circumference of the earth. This estimate, for it does not appear to represent an independent determination, although considerably too small is of interest because it was used by Columbus. Not only did Columbus underestimate the size of the earth, he also overestimated the eastward extent of the Asiatic continent which is why he concluded Eastern Asia would be reached at no great distance by sailing westward.

The Arabs in the ninth century, made a determination of the circumference of the earth which was probably more accurate than that of Eratosthenes.

Although he seems to have been anticipated by nearly 40 years by Tycho Brahe, Snell, who discovered the sine law for the refraction of light and styled himself the Batavian Eratosthenes, is generally credited with being first to introduce the method of triangula-

tion employed in modern geodetic surveys. Snell published in 1617 at Leyden the results for the length of a degree obtained by the new method. No great precision was obtained by either Tycho Brahe or Snell.

In 1669 Picard began the measurements of an arc of a meridian which became celebrated for a number of reasons. Triangulation was employed. It was the first arc on which the telescope with cross wires and microscopes was used. Picard was followed by the Cassinis, father and son, who gradually extended the measurements and improved on Picard's methods.

In the first edition of the Principia, Newton showed that, due to rotation, the earth has the form of a spheroid flattened at the poles. The length of a degree on such a surface increases from the equator to the poles and measurement of a degree of latitude on it in both low and high latitudes serves to determine both the size of the earth and the polar flattening. Newton also determined the amount of flattening on the assumption that the earth is homogeneous throughout and found it to be one part in two hundred and thirty. It is now known that flattening is one part in 297 and this is proof that the earth is not homogeneous, a fact that was of course well known to Newton.

Newton's views which were shared by Huyghens, did not at once receive general acceptance. They were supported by the observation of Jean Richer whose clock, regulated to keep time in Paris, lost two and one half minutes per day at Cayenne, about five degrees north of the equator in French Guiana. They were apparently contradicted by the results obtained by Picard and Jacques Cassini. Their measurements, although subsequently discovered to be in error, indicated that a degree of latitude was shorter in northern France than in southern France. The midpoint of the southern degree was situated at approximately latitude 46 degrees and that of the northern degree at latitude 50 degrees. It is concluded from our present knowledge of the figure of the earth that normally the length of this northern degree would be about 250 feet greater than the southern one. Cassini found it to be 900 feet shorter and concluded the earth was prolate, elongated at the poles. This statement on so great authority as that of Cassini found at the time many adherents and the scientific world was divided for some time into hostile camps, 'the earth flatteners' representing the views of Newton, Huyghens

and others on the one hand, and the 'earth elongators' representing the views of Cassini and his followers on the other.

On either spheroid the length of a degree of latitude varies only gradually from the equator to the pole. To obtain an easily measurable difference in the length of a degree and to reduce the influence of inevitable errors of observation it is therefore necessary to make measurements at places differing considerably in latitude. To settle the question of the form of the spheroid the Paris Academy of Sciences therefore sent expeditions one to Peru in 1735, to which Bouguer and other members of the Academy were attached and another to Lapland, in 1736, in charge of de Maupertuis. The immediate purpose of the expeditions was to determine the length of a degree of latitude at each place.

The Lapland degree was found to be considerably longer showing the earth to be flattened at the pole and thus confirming Newton. Summing up the resulting situation Voltaire remarked in characteristic fashion that de Maupertuis had flattened not only the earth but the Cassinis as well. Referring to de Maupertuis on another occasion he wrote:

> "You choosing mid those frozen wastes to roam,
> Confirmed what Newton found who stayed at home."

Although the question of the nature of flattening of the earth had been definitely settled, the amount of the flattening was far from accurately determined and remained so for some considerable time.

II

In more precise language the expression 'The Figure of the Earth' may have either one of two meanings.

[1]The mathematical figure most nearly approaching the form of mean sea level or [2]this mean sea level surface itself. This latter surface is called the geoid. Over three quarters of the earth's surface the geoid corresponds to mean sea level. Over the remaining one quarter, beneath land, it is an imaginary surface defined by spirit levelling. Its level under the continents is that which would be taken by sea water in imaginary narrow channels or canals connecting the water of the oceans.

It is concluded from the data available at the present time that the above mentioned mathematical figure is an oblate spheroid, that obtained by revolution of an ellipse about its minor or shorter axis. Dimensions of a spheroid were adopted, by international agreement in 1924, to better co-ordinate the work of geodetic surveys throughout the world. The accepted values, to the nearest mile, are equatorial radius 3,963 miles, polar radius 3,950 miles and flattening 1/297. The flattening is defined as the difference between the two radii divided by the equatorial radius.

The dimensions of the international spheroid were derived solely from the results of geodetic surveys in the United States. Although those surveys cover only a comparatively insignificant fraction of the earth's surface, there is nevertheless reason to believe that the adopted values for the spheroid are reasonably accurate.

The form of the geoid, its elevation or depression with respect to the spheroid, may be determined on land by deflections of the vertical. For any place, this deflection is the angle between the direction of the true or actual vertical (the plumb line) and the direction of the vertical derived from the results of geodetic surveys.

The variation of gravity over the surface of the earth is determined to a large extent by the shape of the earth. Consequently gravity observations provide data for determination of the earth's figure. Clairaut (1713-1765), celebrated French mathematician, showed how gravity may be used to determine the flattening and this is perhaps the most direct and accurate method. Stokes (1819-1903), distinguished British mathematician and physicist, explained how the form of the geoid may be obtained from measurements of gravity.

An accurate determination of the form of the geoid cannot yet be made because of the present lack of a suitable distribution of gravity observations over the entire surface of the earth. An investigation of the problem by R. A. Hirvonen of the Geodetic Institute of Finland indicates that there are, however, at present, sufficient observations to give an idea of the order of magnitude of the geoidal undulations and their geographical location. Employing the results of gravity determinations available in 1934 Hirvonen concluded that the warping of the geoid from the spheroid does not generally exceed 100 metres and that the geoid is on the average not more than 50

metres above or below the spheroid. The gravity results suggest that the equator is not a circle but an ellipse with one extremity of the major axis terminating at a point about 20 degrees west of Greenwich. The major axis appears to be 140 metres longer than the minor axis.

Hirvonen also found the geoid to be above the ellipsoid on the Atlantic and on the Pacific Oceans contrary to the general opinion that the surface of the sea is below the ellipsoid.

Several astronomical methods have been used to determine the flattening. They depend, for the most part, on the mechanical effects produced by the earth's equatorial bulge. Observation of these effects thus provides a method for computing the equatorial bulge or the flattening. The value deduced from the precession of the equinoxes agrees precisely with that of the international ellipsoid and that deduced from gravity observations. Perturbations in the motion of the moon, due to the ellipticity of the earth, have also been used to compute the flattening and yield values only slightly in excess of the accepted value which is not a little remarkable considering the theoretical difficulties involved in all the astronomical methods.

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Dominion Observatory,
Ottawa, Canada.

PLATE V

D. A. O. Group Picture, September 17, 1945

Left to Right: Miss J. K. McDonald, Mrs. C. S. Beals, C. S. Beals, Mrs. Bancroft, Patricia Petrie (6 yrs.) Dr. Silver Keeping, John Keeping (3 yrs.), S. S. Girling, Mrs. R. M. Petrie, Robert Petrie (2 yrs.), Prof. E. S. Keeping, Richard Pearce (9 yrs.), Josephine A. Pearce, R. M. Petrie, James Duff, Mrs. K. O. Wright, Nora Wright (3 yrs.), K. O. Wright and J. A. Pearce.

The above D.A.O. photograph will be of interest to readers of the Journal and to the colleagues of the staff. It was taken on September 17, 1945. The purpose of the gathering was to welcome Lt. Cdr. and Mrs. R. M. Petrie who had just rejoined the staff after an absence of nearly two years and also to say good-bye to Professor and Mrs. E. S. Keeping who were leaving for Edmonton after their summer sojourn at the Observatory. Mr. James Duff of Sidney, a Past President of the Victoria Centre and a frequent visitor to the Observatory, attended this gathering. The only absent members of the staff were Mr. H. W. Dukeman and Lt. Cdr. and Mrs. Andrew McKellar and their young son, Robert Andrew, who returned to the Observatory the following week.

REPORT OF THE DOMINION ASTROPHYSICAL OBSERVATORY FOR THE YEARS 1942-1945

By J. A. Pearce

(With Plate V)

1. *War Work.* During these war years, all members of the staff made contributions to the war effort. Dr. Andrew McKellar and Dr. K. O. Wright, each spent an academic year at the University of British Columbia, instructing army officers in Mathematics and Physics. Dr. C. S. Beals, as Provincial Gas Officer, 1943-1945, and Dr. R. M. Petrie as Gas Identification Officer, 1943, devoted a great portion of their time to Civilian Defence duties. Courses in the chemical identification of the war gases were arranged by Dr. C. S. Beals for provincial chemists in Vancouver and Victoria. Courses in the war gases were given to instructors in various provincial centres: Vancouver, Victoria, Nanaimo, Port Alberni, Beaver Creek and Ladysmith, and some 400 certificates were granted to officers who successfully passed the written A.R.P. examinations. Mr. W. H. Stilwell assisted the Geodetic Service in their survey of new air fields in the Hudson's Bay area in 1944 and 1945. Mrs. J. A. Pearce was an Official Observer with the Aircraft Detection Corps from January 1942 to February 1945. Dr. Pearce devoted two evenings a week during 1943 and 1944 as an instructor with the 203rd Battery Royal Canadian Artillery. A daily time service was maintained for the convenience of the R.C.A.F. and R.A.F. units at Patricia Bay Air Field.

Early in 1944 Dr. A. McKellar, and later Dr. R. M. Petrie, were transferred to the National Research Council and seconded to the Directorate of Operational Research, Royal Canadian Navy. They were commissioned Lieut. Commanders and for nearly two years were posted to the Atlantic Command. Each made valuable contributions to the anti-submarine warfare in the Atlantic, Lieut.-Commander Petrie being posted to Halifax and St. John's, Newfoundland, and Lieut.-Commander McKellar to Naval Headquarters and for some months to Admiralty.

2. *Staff.* Many changes occurred during these years. Miss Elizabeth C. Walker, B.A. (McMaster), was appointed an Astronomical Assistant in May 1942, relinquishing the position upon her marriage to Mr. W. H. Stilwell in September, 1943. Miss Jean K. McDonald, B.Sc. (Alberta), joined the Staff in October, 1943. Mr. T. T. Hutchison, Engineer and night assistant for 28 years, was superannuated in March, 1943. Mr. S. S. Girling of Victoria, B.C., who for 15 years had constructed many instruments for the Observatory, was appointed Instrument Maker in March 1943. Mr. W. H. Stilwell was loaned to the Geodetic Service of Canada, May, 1944, and resigned April 15, 1945, to accept a position of Surveys Engineer. Mrs. J. A. Pearce died on May 13, 1945, following a three month illness. The P.E.O. Sisterhood have given a Bursary to Victoria College, in order that the Esther Pearce Memorial Prize in English may be awarded annually in her memory.

During the summers, a number of Canadian scientists visited the Observatory to pursue research problems. These included Miss A. B. Underhill, B.A., Dr. W. and Mrs. Petrie and Dr. H. D. Smith (University of British Columbia) and Professor E. S. and Mrs. Keeping (University of Alberta).

3. *Observations.* While the astronomical work of the Observatory has been greatly retarded, due to a reduced staff, the observations with the 73-inch reflector have been maintained at nearly normal efficiency. During recent years, the winters have been very mild, and the skies more overcast with clouds than usual with a subsequent reduction in available observing time.

Observing Statistics, 1942-1945

Year	*Nights*	*Hours*	*Plates*
1942	184	1117	923
1943	168	1118	1013
1944	188	1100	1740
1945	140	834	1089
27 year average 1919-1945.	196	1209	1285

4. *Instruments.* The instrumental resources of the Observatory have been greatly developed by the construction of a number of new instruments. The 84-inch aluminizing chamber was completed in 1943, and the 73-inch primary and 20-inch secondary mirrors were

successfully aluminized by Dr. McKellar. Tested with a photoelectric reflectometer, devised by Dr. Beals, the reflectivity of the coat at λ3900 was 82.6% as compared with 65% for freshly deposited silver. A gain of one stellar magnitude has been achieved and spectra of the 11th magnitude may now be obtained in reasonable time. Improvements were made in the 24-inch aluminizing apparatus, and several mirrors, including the 13-inch Wates mirror of the University of Alberta, were aluminized.

Dr. C. S. Beals, with the assistance of Dr. Petrie and Dr. McKellar, completed the modification of the three-prism spectrograph from a Universal to a Littrow form designed to make use of either prisms or gratings. Tests for flexure of the cantilever member which formerly carried the slit assembly, but which now carries the cameras as well, indicated that the amount is satisfactorily small. The new instrument has more than fulfilled our expectations in its performance, particularly with the two aluminum-on-glass gratings ruled by R. W. Wood. Dispersions of the 1st, 2nd and 3rd orders are 15, 7, and 4.5 A/mm., respectively. Eight inches of the spectrum may be photographed at one exposure and stars of the fifth magnitude observed with the highest dispersion. A three-inch flat mirror for the Littrow spectrograph was figured and aluminized by Dr. Petrie. When tested it was found to be correct within a quarter wave-length of light.

The two-prism Hilger ultraviolet spectrograph formerly used at the prime focus of the 73-inch telescope, has been redesigned and constructed by Mr. S. S. Girling for use at the Cassegrain focus. This instrument has a dispersion of 99 A/mm. at λ3933 and has been chiefly employed as a slitless spectrograph for the investigation of the colour temperatures of early type stars.

The intensitometer has been altered in order to make it possible to derive rectified line profiles without computation. Mr. Girling has prepared five logarithmic curves etched upon glass which permit true intensity curves to be derived from an initial curve giving the intensities on a logarithmic scale. The intensity scale, the axis of abscissae, covers 10 inches while the logarithmic scale, the axis of ordinates, is somewhat over five inches. In addition to the curve an intensity scale 1 to 10 inches subdivided into 1/10 inches is also superimposed on the glass plate. With the aid of this scale the continuous spectrum of the star can be set at any intensity value

from 0.1 inch to 10 inches and the deviations from this value represented by absorption or emission lines are faithfully drawn by the instrument as the tracing passes through. For the continuous spectrum set at 10 inches the errors of intensity due to faulty drawing or placement of the curve were found to be not greater than one-tenth of one per cent. For the continuous spectrum set at lower values the errors increase proportionally but in no case are they comparable to the uncertainties due to the properties of the photographic plate itself. The use of the curves etched upon clear glass in place of those drawn in pencil on ground glass has greatly improved the optics of the instrument, resulting in increased speed and accuracy.

A new projection machine has been devised by Dr. R. M. Petrie which promises to eliminate a great deal of the labour involved in measuring spectrograms for radial velocity. The principle of the new device is the reduction of the spectrum by optical and mechanical means to a standard dispersion. The micrometer settings upon the comparison lines are eliminated and the process of reducing the measures is so simplified that a great saving of time results. The radial velocities measured by this new projection method are satisfactorily accurate.

5. *Radial Velocity Investigations.* The observation of the class B stars, fainter than 7.5 magnitude, and north of declination +20° was continued, the Cygnus, Cepheus and Taurus regions being especially observed. In order to study the distribution of velocities perpendicular to the galactic plane, a new programme of some 250 A0 to F5 stars, of magnitudes brighter than 9.5 near the north galactic pole, was compiled. During the last season some 130 spectra of these stars were secured.

(*a*) *Radial Velocity Standards.* A re-examination of wave-length standards has been in progress for some time and new tables of accurate velocity standards have been determined by Dr. R. M. Petrie for spectral types F5 to K5 for high dispersion (11 A/mm. at Hγ) and moderate dispersion (30 A/mm. at Hγ). The wave-length system is based upon solar wave-lengths as given in the *Revised Rowland* and values are chosen so as to reproduce velocities in the solar system and also those of the I.A.U. standard velocity stars. The high-dispersion table is based upon 92 spectrograms and gives a mean residual Victoria-standard = −0.3 km./sec. The moderate

dispersion table is based upon measures of 80 spectrograms and gives a mean residual of Victoria-standard = −0.4 km./sec. It is felt that these remaining residuals are caused, at least in part, by flexure effects and investigations are being made to test and evaluate this source of error. The wave-length study has shown very clearly that standards must be derived separately for each dispersion used, at least for solar-type spectra.

(*b*) *Curvature Correction.* Miss J. K. McDonald re-determined the curvature correction to be applied to radial velocities obtained with our spectrograph, confirming the adopted value of −0.70 km./sec. for the photographic region of the spectrum.

(*c*) *Pleiades Cluster.* Over 400 spectra have now been obtained by Dr. Pearce of 71 members of the cluster, the observations being completed to the 10th magnitude. The radial velocity of the cluster deduced from 320 observations of the 12 brightest stars was found to be +7.86 km./sec. The apparent convergent point of the proper motions was found to be at (1950), $\alpha = 84°$, $\delta = -34°$, approximately 10° distant from the solar motion antapex. Most of the observed proper motion is therefore a parallactic drift. The centennial proper motion of $5''.07 \pm 0''.04$ is in position angle $\phi = 153°.2 \pm 0°.6$. The absolute motion of the cluster was found to be 3.3. km./sec. towards the apex (1950) $\alpha = 307°$, $\delta = -4°$. A computed radial velocity for the cluster = +7.7 km./sec.

The parallax of the cluster determined from the proper motions was found to be $0''.0138$, in good agreement with the trigonometric parallax of $0''.014 \pm 0''.002$, and the spectroscopic parallax of $0''.012 \pm 0''.003$. The mean distance of the cluster is therefore approximately 75 parsecs.

(*d*) *Taurus Cluster.* Mr. W. H. Stilwell measured 231 plates of 17 members of the Taurus cluster in order to study the reported variability of these stars. Nine stars previously considered variable were found to have a constant velocity. The observed mean velocities were in good agreement with Smart's computed velocities for these stars.

6. *Spectrographic Binaries.*

(*a*) *HD 144208-9.* Dr. R. M. Petrie made an interesting study of this composite binary system. The system comprises a solar-type primary dF9 and faint A0 secondary revolving in circular orbits in a period of 108 days. The K line only of the faint secon-

dary star was measured, being revealed through a spectral window created by the wide, strong absorption of the primary spectrum at that region. A method was devised, based upon spectral-line profiles for the determination of the light ratio, $\Delta m = 1.2$ mag., and temperature of the fainter star, $T_f = 12500°$K. The fainter component was found to be a sub-dwarf, having a luminosity one one-hundredth that of a normal A0 star, much smaller than such a star and many times denser.

(*b*) *HD 227696.* Orbital elements for the 8th magnitude eclipsing variable were deduced from 25 observations secured in 61 days by Dr. Pearce. The absolute masses and dimensions of the component stars were determined from a spectrophotometric determination of the magnitude difference, $\Delta m = 0.52$. The masses are large, $m_1 = 16.7\odot$ and $m_2 = 12.8\odot$. The radii and densities are: $R_1 = 6.6\odot$, $\rho_1 = 0.06\odot$; $R_2 = 5.2\odot$, $\rho_2 = 0.09\odot$. The spectrographic elements precisely represent Ashbrook's photometric minimum, J.D. 2427242.87 for this recently discovered variable.

(*c*) *HD 180939.* New orbital elements for the brighter component of this eclipsing variable, RS Vulpeculae were deduced by W. H. Stilwell from 29 observations secured in 1936-38. A spectrophotometric analysis of the profiles of six spectral lines indicated that the secondary was 3.1 magnitudes fainter than the primary. Lines of the secondary spectrum were faintly observed on several of the plates. By adopting Gaposchkin's photometric elements the values $M_1 = 4.5\odot$, $M_2 = 1.4\odot$; $r_1 = 4.1\odot$, $r_2 = 5.4\odot$; and $\rho_1 = 0.016\odot$, $\rho_2 = 0.002\odot$ were deduced.

(*d*) λ *Andromedae.* Definitive elements were deduced from the Lick Observatory 3-prism observations of this binary by Dr. Pearce, after applying systematic corrections to Burn's observations of 1898-1906. The new elements satisfactorily represent all observations and confirm Luyten's suggestion that the binary is a simple two-body system. An absolute magnitude of +1.96 was found, indicating that this G6 star is a subgiant. The spectrum contains numerous strong, sharp metallic lines, H and K of ionized calcium being in emission.

To investigate the suspected apsidal motion, a new series of high dispersion spectrograms was secured by Pearce from 1938-1942. The 27 plates were independently measured by Miss E. C. Walker and Dr. Pearce using wave-lengths which satisfactorily reproduce

the velocities of the standard stars *Aldebaran* and *Arcturus*. Twenty standard velocity plates measured by both observers showed that no appreciable personal equation existed. In 1938-42 orbital elements were in perfect agreement with the 1898-1906 elements showing that no detectable changes had occurred during the intervening 40 years.

(*e*) *HD 193576*. Professor E. S. Keeping computed the orbital elements of the massive Wolf-Rayet eclipsing binary HD 193576. This interesting system consists of a W6 star of temperature 80,000,° surrounded by an expanding envelope of hydrogen and helium, and a normal absorption O6 star of temperature 40,000,° revolving in a circular orbit in a period of 4.21 days. The radial velocities were determined by micrometer measurements of 55 microphotograms Considering the complex character of the spectrum, in which wide emission lines of the W6 star are associated with an O6 absorption spectrum, more trustworthy radial velocities could be obtained by measuring the microphotograms giving a 20-fold enlargement of the spectrum. A solution for the elements using Schlesinger's equation of condition showed that the orbit was nearly circular, so that a second solution by Sterne's method was used to derive the final elements:

$V_0 = +38.4 \pm 2.6$; $K_1 = 172.6 \pm 5.5$; $K_2 = 306.7 \pm 5.6$ km./sec.;
$e = 0.026 \pm 0.014$; $\omega_1 = 13°.9 \pm 33°.4$ and
T = J.D. 2430569.092 $\pm$ 0.394.

(*f*) *HD 34333*. An important discovery of a massive eclipsing system was made by Dr. Pearce. Thirty observations of the 8th magnitude star HD 34333, Aurigae were secured in a four month period. A solution of the observations by Sterne's method gave elements identical with the following deduced by the Lehman-Fihlés equation of condition:

$P = 4.0657$ days; $V_0 = -1.1. \pm 1.1$; $K_1 = 226.9 \pm 1.7$;
$K_2 = 227.5 \pm 2.4$ km./sec.; $e = 0.05 \pm 0.01$; $\omega_1 = 51°.1 \pm 8°.2$;
and T = J.D. 2430734.4448 $\pm$ 0.0932.

A value of $\Delta m = 0.45 \pm 0.07$ was determined from line profiles of λλ4471, 4341, 4101 and 4026 on six plates. The measured intensity of the interstellar K line $W = 0.36$ E.A. gave a distance of 1080 parsecs for the system. The following dimensions were deduced. For the primary star—$M_1 = 23.2\odot$, $R_1 = 8.2\odot$, $\rho_1 = 0.04\odot$

and $M_v = -3.06$. For the secondary star—$M_2 = 23.1\odot$, $R_2 = 6.6.\odot$, $\rho_2 = 0.08\odot$ and $m_v = -2.61$. The star was not known to be an eclipsing variable but from the spectrographic study an inclination of 71° was deduced and a small eclipse of 0.05 magnitude predicted. This was subsequently verified by Gaposchkin who observed the star and determined a photographic light curve. Sterne's theory gives a predicted apsidal period of 77 years.

7. *Spectrophotometric Investigations.*

(*a*) *Wolf-Rayet Stars.* A very thorough investigation of the important Wolf-Rayet binary HD 193576 was made by Dr. Beals. Equivalent widths were derived for all readily observable emission bands and absorption lines in the region λλ3900-6700. The absorption line component was classified as O6 and the emission line component as WN 5.5. Comparison of the observed intensities of the emission and absorption lines led to apparent magnitudes of 8.6 for the O star and 10.3 for the W star and absolute magnitudes of -2.8 and -1.3 respectively. The distance of the system was found to be 3800 light years from the interstellar K line.

The emission bands of the Balmer and Pickering series were shown to exhibit asymmetrical profiles near phases 0.0 and 0.5 similar to those described by Wilson for λ4686. It is suggested that this may be a consequence of tidal action in an expanding envelope surrounding the W star.

Absorption lines accompanying Hα and Hβ displaced to the red approximately 1800 km./sec. suggest the presence of an absorbing envelope of He II smaller in radius than the distance between the two stars. Variations with phase of the absorption line displaced 400 km./sec. to the violet of the He I line λ4471 could be accounted for by assuming an envelope greater in radius than the distance between the two components. Its displacement suggests that the ejected atoms have suffered a retardation of their velocities due to the gravitational action of the two stars. Dr. Beals found the diameter of the O star to be $4.1\odot$, but uncertainty regarding the effective temperature and probable heavy darkening at the limb of the W star leaves its size indefinite.

(*b*) *P Cygni Stars.* An extended study of all P Cygni stars observable at Victoria has been brought close to completion by Dr. Beals. The data consists in part of tables of radial velocity and equivalent widths and in part of profiles of P Cygni type lines.

1. ***Classification.*** While the P Cygni stars range in type from Class O to Class F, the late Class B stars having a helium spectrum associated with sharp lines of ionized metals is most frequent. Thus the star P Cygni, while giving its name to the group, shows marked differences from most of the other stars being of higher excitation and giving evidence of a much greater optical thickness than most of the other stars.

2. ***Line Profiles.*** Four fundamental types of profiles have been recognized as typical of P Cygni objects and numerous variations of these fundamental types have been observed. The interpretation of these profile types represents the main problem in the study of these stars.

3. ***Absolute Magnitude.*** While early studies indicated high absolute magnitudes for the group, a more detailed investigation reveals the presence of numerous objects of relatively low intrinsic brightness suggesting that the original conclusion was, to some extent, a discovery effect.

4. *Variability.* Many of the stars show variability in light or spectrum, or both. The spectrum variability affects the positions, the forms and intensities of the lines. The origin is mysterious and thus far no satisfactory explanation of its cause has been forthcoming. Both the peculiar profiles of these stars and their variability point to some lack of equilibrium in the output of energy. It is probable that a complete explanation of these phenomena would shed valuable light on the general problem of the sources of stellar energy.

(*c*) *MWC 374.* A detailed analysis of the spectrum of this P Cygni object was made by Dr. Beals. The profile of Hα consists of two emission maxima of greatly differing intensity, the stronger of the two being to the red. The remaining members of the Balmer series are normal P Cygni type lines, but the emission peaks (which coincide in velocity with the stronger emission maximum of Hα) are shifted 60 km./sec. or more to the red of the normal position as determined from other features of the spectrum. Evidence is presented which indicates that the unusual profile of Hα and the displacement to the red or other emission lines of the Balmer series are due to absorption by a layer of atoms located at a greater height above the stellar surface than the stratum responsible for emission. The study shows that redward displacements of emission line profiles indicates

that the absorbing atoms are subject to a retardation of their velocities in passing outward from the region of emission to that of absorption while an undisplaced profile is an indication of accelerated motion.

(*d*) *HD 190603.* A recent study of the spectrum revealed the P Cygni characteristics of this star. Differences between the hydrogen line velocities and those of other atoms show that the star is surrounded by a shell of outward moving hydrogen atoms. Hα and Hβ appear as P Cygni emission lines while the velocities of higher members of the Balmer series are shifted to the violet by absorption in the shell. The lines of helium show a similar effect though to a less marked degree.

(*e*) *Stark Effect.* Miss A. B. Underhill studied the Stark Effect of helium in some B-type stars. Fifty-four spectra of three giant and three dwarf stars were obtained and the equivalent widths of the He I diffuse lines determined from 75 microphotograms. A decided weakening of λ5876 and λ6678 in the spectra of the dwarf stars was found. This supports the cycle proposed by Foster and Douglas to explain the anomalous absorption near λ4471 and λ4922 in the dwarf class B stars. This research was accepted by the University of British Columbia as Miss Underhill's thesis for an M.A. degree.

(*f*) *Spectral Line Intensities in O-type Stars.* Intensities of the principal absorption features in the ordinary spectral region were determined for sixteen O-type stars by Dr. R. M. Petrie. The number of O-type stars so studied is substantially increased by these measurements. The variation, with temperature, of the line intensities is considered for the purpose of classifying spectra of low dispersion and useful ratios were found in the lines of ionized and neutral helium. The behaviour of the hydrogen lines suggests that they may not exhibit a luminosity effect similar to that observed in the B stars.

(*g*) *Δm Determinations.* A spectrophotometric investigation of the magnitude difference between the components in 21 spectrographic binaries was made by Dr. R. M. Petrie. The values of the light-ratio vary from 0.88 to 0.11 and the spectral types from O8 to F6. These data permit the luminosities and masses of the individual stars to be calculated. Utilizing the material from 23 systems previously studied a relation between the light-ratio and the ratio of

the masses was established. The large range in relative luminosity covered is an important contribution to the mass-luminosity relationship of spectrographic binaries.

(*h*) *Temperature Gradients of the W and B Stars.* A study of the gradients of faint early type stars, for the purpose of investigating space absorption, was commenced. Over 500 spectra of the 6th to 8th magnitude stars were secured with the slitless ultraviolet spectrograph and it is proposed eventually to extend the programme to stars of the 10th and 11th magnitude. Gradients were determined from 300 spectra of 8 Wolf-Rayet and 12 Class B stars in Cygnus by Dr. Wm. Petrie, the measurements being made in four spectral regions between λλ6400-3400. The results obtained indicate that the temperature of a W star varies with the comparison B star used, suggesting a differential space reddening effect. In order to obtain the true temperature, the distance effect must of course be eliminated, and Dr. Petrie hopes next summer to obtain sufficient observations to complete the research.

(*i*) *HD 199140.* The central absorptions and equivalent widths of the hydrogen and helium lines in this β Cephei star were measured by Dr. R. M. Petrie on 44 spectrograms distributed over the cycle of light and radial velocity variation. It was found that (1) all lines show a periodic variation in central depth, the lines being deepest and sharpest at the time of greatest atmospheric expansion; and (2) the lines of hydrogen show a variation in total absorption, being strongest at time of maximum expansion. No well established variation was found in the intensities of the helium lines.

The variation in line depths is interpreted as a Doppler effect, while the changes in total intensity are explained as a spectral class effect.

8. *Solar-type Stars.*

(*a*) *Solar Curve of Growth.* Dr. K. O. Wright continued his studies of the atmospheres of solar-type stars. When theoretical line intensities, predicted for LS coupling, are plotted against observed laboratory intensities corrected for wave-length differences, serious discrepancies are observed; as the laboratory values are considered accurate to within ten per cent., it appears that the theoretical values are in error. A revised curve of growth for the sun was derived from the best available equivalent width data,

those of Allen and the Utrecht Photometric Atlas, with King's *gf* values for Ti I and Fe I and from Seward's laboratory emission intensities for Mn I. The curve is appreciably different from that obtained when theoretical intensities are employed. Excitation temperatures for the reversing layer of the sun are found to be 4550°± 125°K. for Ti I lines and 4900°± 125°K for Fe I lines; this difference appears to be real. Solar *gf* values may be calculated for any atomic line with a known solar equivalent width if an excitation temperature of 4700°K is assumed.

(*b*) *Excitation Temperatures of Giants and Dwarfs.* Solar line strengths derived from the revised curve of growth were calculated for 638 lines in the spectral region λλ4028-6752 on high dispersion spectrograms of the sun, Gamma Cygni, Alpha Persei and Alpha Canis Minoris, and new curves of growth derived for these stars. Values of the turbulent velocities and excitation temperatures have been attained and Unsöld's treatment of Sahas' ionization theory used to obtain electron pressures and the level of ionization in these stellar atmospheres. The principal results are listed in the following table, and suggest:

1. That turbulence is greater in giants than in dwarf stars.
2. That excitation temperatures are higher in giants than in dwarf stars of the same spectral type, and
3. That the composition of these stellar atmospheres is remarkably uniform.

THE ATMOSPHERES OF SOLAR-TYPE STARS

	Sun dG_2	*γ Cygni* cF_7	*α Persei* cF_4	*α Can. Min.* dF_2
Turbulent Velocity V_T km./sec.	1.6	6.6	5.8	2.2
Damping Constant, Γ, sec^{-1}...	2.1×10^9	2.1×10^9	3.1×10^9	1.8×10^9
Excitation Temperature $T°$, K..	4600	5300	6000	5500
Electron Pressure, P_e, bars	1.0	1.2	14.5	9.0
Level of Ionization, χ, volts ...	8.0	9.3	9.3	8.6

The above data were derived from curves of growth in which theoretical line strengths were used. When solar *f*-values are combined with the observations, the following temperatures are obtained: sun 4600, γ Cygni 4400, α Persei 4700 and α Canis Minoris 4800°K. A revision of the remaining data is now in progress.

(*c*) *Atmosphere of Alpha Persei.* From a series of high-dispersion plates, Dr. Wright has measured the intensities of more than 1000 lines in the spectrum of Alpha Persei. These intensities have been combined with *gf*-values from a solar curve of growth to form curves of growth for Alpha Persei. Real differences between the curves for the various atoms appear to exist, indicating (1) that temperatures for neutral atoms is in general higher than those for ionized atoms (2) the damping factor is always greater for neutral than for ionized atoms, and (3) the turbulent velocities for neutral atoms are always less than those for ionized atoms in this star. These conclusions are in agreement with the concept of a stratification in the atmosphere of Alpha Persei.

9. *Photometric Observations.* The photoelectric photometer was used on 47 nights, 1100 observations being secured, thus bringing to completion the observations of the photoelectric colour indices of the 250 O- and B-type stars for which gradients had been determined by the Greenwich observers.

10. *Cometary Studies.*

(*a*) *Intensity Measurements on Emission Bands in Cometary Spectra.* Intensity profiles of the violet CN bands in the spectra of Comets 1939d and 1940c and of the λ4315 CH band and λ4737 sequence of C_2 Swan bands for comet 1940c were derived by Dr. McKellar.

It was shown that the unusual structure of the CN bands was accounted for by a recent hypothesis of Swings. This hypothesis requires that the cometary bands be produced by resonance-fluorescence and that the intensity contour of the exciting radiation (the solar spectrum) be taken into account. The agreement of the observed profiles of the CN bands with those calculated on the basis of the fluorescence mechanism provides direct confirmatory evidence that the emission bands are produced by this mechanism.

The validity of the resonance-fluorescence mechanism having been demonstrated, the observed profile of the λ4315 CH band in the spectrum of Comet 1940c was used to calculate the distribution of CH molecules among the rotational levels of the normal $^2\pi$ state. The results indicated that at a heliocentric distance $r = 0.54$ astronomical units, they were in the two lowest states $K'' = 1$ and $K'' = 2$ and that they were about evenly divided between these two states.

(*b*) *Cometary Emission Spectra in the Visual Region.* The visual spectral region (above λ5000) has heretofore been relatively neglected in studies of cometary spectra. One spectrogram of Comet 1940c and six of Comet 1942g covering the visual region were obtained at Victoria and the cometary emission features measured. In collaboration with Dr. P. Swings of the McDonald Observatory and Dr. R. Minkowski of the Mount Wilson Observatory, who were making similar measurements, Dr. McKellar studied the cometary emissions in the region λ4800 to λ7000. Over 80 emission features were listed altogether. It was noted that a number of the stronger features behaved as emissions from polyatomic molecules might be expected to do, with change of comets' heliocentric distance. The cometary spectrum was compared with that of an oxyammonia flame. This led to the suggestion that the strong "λ6300 group" of radiations and possibly some others are due to a dissociation product of ammonia, probably NH_2.

(*c*) *Cometary Spectra. Comet 1942g.* Wave-length measurements on eight excellent spectra of Comet Whipple-Fedtke-Tevzadze were made by Dr. McKellar. The spectrograms, obtained with relatively high spectral purity, (projected monochromatic image of the slit on the plate approximately 0.5 angstroms for λ3880), cover the ordinary photographic region. For the first time in cometary spectra, the line λ3883, emission band of CN, has been partially resolved, the individual lines of the R branch, R(1) to R(12) being clearly separated. The great strength and increased resolution of the λ4050 group of CH_2 bands at the large heliocentric distance 1.4 astronomical units allowed more fruitful study of its fine structure to be made than heretofore possible.

While the emission line at λ4752 in other comets has been attributed to the $C^{13}C^{13}$ isotopic carbon molecule, the relatively low intensity of the main $C^{12}C^{12}$ Swan system in comet 1942g and also the absence of the $C^{12}C^{13}$ band head at λ4745 would suggest that the feature measured at λ4752 is not due to the isotopic carbon molecule $C^{13}C$.[13]

No reasonable identification was found for a dozen emission features observed; the occurrence of CH_2 and NH_2 bands in cometary spectra would suggest the possibility that the majority of these unidentified features arise from polyatomic rather than diatomic molecules.

(*d*) *CN Band in Comets 1940c and 1942g.* A comparison of the structure of λ3883, 0.0, CN band in the spectra of Comet 1940c and Comet 1942g was made by Dr. McKellar. The wave-length measures were homogeneous in all important respects, as they were made by the same observer on spectrograms taken with the same instrument and with the same slit-width. This is significant since the separation between the adjacent lines in the R branch of the CN band, approximately 0.6-0.8A, is of the same order as the spectral purity used. The measured differences in the structure of the band for these two comets were adequately explained, taking into account the effects of the different heliocentric distances, and the different radial velocities of the comets with respect to the sun. The differences were discussed in terms of the resonance theory of the production of the bands, taking into account the contour of the solar spectrum as suggested by Swings.

11. *R- and N-Type Stars.*

(*a*) *Resonance Lines of Li I and Na I in the Carbon Stars.* A study of the λ6708 and λ5890 regions of spectrograms of over 40 red carbon stars obtained at Victoria was made by McKellar and Stilwell. Supplemented by date from Dr. R. F. Sanford obtained at Mount Wilson, the results indicate that:

1. Spectra of nearly all these stars show evidence of absorption by Li I atoms at λ6707.84 although blending with a CN line at λ6707.51 gives the resultant mean wave-length 6707.68. Only two stars show really strong Li I absorption.

2. The average equivalent width for the sodium D lines in all these spectra is $(D_1 + D_2) = 13$A and for the lithium resonance doublet, correcting for the above blending effect is 0.6A.

3. The available data on line intensities show no marked correlation between Na I and Li I resonance line intensities, or between spectral types and intensities of these lines.

4. The present material does not enable a definite decision to be reached upon whether the very great strength of the Li I ultimate line in the spectrum of WZ Cassiopeiae is a consequence of unusual abundance of lithium or of low excitation conditions.

(*b*) *Carbon Bands in R and N Stars.* Dr. McKellar has continued his research on the C_2 bands, the observational material comprising 150 spectrograms of 35 stars being essentially complete. The primary object of the study is to measure the relative inten-

sities of the 1.0 main $C^{12}C^{12}$ and isotopic $C^{12}C^{13}$ bands of the Swan System at λλ4737, 4744 and 4752 respectively. It is hoped to establish whether the relative abundance of C^{13} to C^{12} in the various stellar atmospheres is different from star to star (and different from the 1 to 100 ratio for terrestrial carbon), or whether the observed great strength of the isotopic bands in some stellar spectra may be due to physical conditions other than abundance.

Some by-products of the main study are receiving attention: (1) determinations of "rotational" and "vibrational" temperatures from intensities in the Ca and C_2 bands, and (2) an examination of the unidentified blue-green bands which were previously studied by Merrill, by Sanford and by Struve.

12. *Solar and Lunar Eclipses, 1945.* Dr. C. S. Beals was a member of the Harvard College Observatory Eclipse Expedition to Bredenbury, Sask., to observe the total solar eclipse of July 9, 1945. Two new cameras were constructed for this eclipse, (1) one by Dr. K. O. Wright for taking direct photographs of the corona, and (2) one by Dr. C. S. Beals for taking Kodachrome motion pictures. For the latter instrument a 3-inch Moffit *f*3 lens was used as an objective combined with a commercial 16-mm. motion picture camera, mounted upon the equational mounting of a 4-inch Mogey refractor, but unfortunately, clouds prevented the carrying out of the ambitious programme of spectrographic and photographic observations planned by Dr. Menzel and his associates.

The total eclipse of the moon which was observed at Victoria on the evening of December 18th under ideal atmospheric conditions presented an opportunity of testing out the motion picture camera. The camera was mounted upon the tube of the 73-inch reflector. Some 3500 exposures were made on 85 feet of Kodabromide colour film—400 exposures of the moon during total phase and 3100 as the moon was leaving the umbra. Dr. Beals operated the camera, Dr. Petrie did the guiding with the 6-inch finder and Dr. McKellar the timing and recording. All pictures were in good form and a satisfactory picture of the eclipse was obtained. The colour of the totally eclipsed moon was a deep red, somewhat darker than the average colour, but probably normal for mid-winter eclipses.

13. *Seismographic Service.* Under the supervision of Dr. Wright the two photographically registering Milne-Shaw seismographs were maintained. Approximately 500 earthquakes were recorded; epi-

centres were computed for a few severe shocks and details announced to the press.

14. *Library.* Dr. Wright, with Miss McDonald's assistance, reclassified the library on a Dewey decimal system. During this period accessions totalled 117 and 164 books were bound.

15. *Visitors to the Observatory.* During these war years with restrictions on gasoline reducing ordinary tourist travel, the number of visitors to the Observatory was greatly diminished. The estimated yearly attendances were: 1942—4,055; 1943—2,867; 1944—5,316; and 1945—14,870, which may be compared with the 27-year average (1919-1945) of 20,985. Approximately half of the visitors were members of the armed forces from the R.A.F. and R.C.A.F. Patricia Bay Empire Training Station, the Officers Training Camp at Gordon Head, troops from Colwood Camp and Esquimalt Fortress and naval personnel from the Royal Naval College and Esquimalt Naval Base. The 2-hour public observation period on Saturday evenings was resumed in September, 1945.

16. *Publications.* The only publication distributed during these years was Vol. VII, No. 15, "Molecular Lines from the Lowest States of Diatomic Molecules Composed of Atoms Probably Present in Interstellar Space" by Dr. Andrew McKellar. It is expected that the ban imposed upon the printing of the Observatory publications, which is still in effect, will be lifted in the near future and the normal distribution of our publications resumed.

Dominion Astrophysical Observatory,
Victoria, B.C.
January, 1946.

THE P CYGNI CHARACTERISTICS OF H.D. 190603*

C. S. BEALS

H. D. 190603, $\alpha(1900)\ 20^h00^m7$; $\delta(1900)\ 31°\ 51'$ is a B0sk star of photographic magnitude 5.7, listed by Merrill and Burwell[1] as an emission line object with bright Hα. The radial velocity as given by Plaskett and Pearce[2] is +18 km./sec. In the ordinary region the spectrum consists of relatively narrow absorption lines due to H, HeI, SiIII, SiIV, OII, NII, NIII and MgII. Data on the equivalent widths of absorption lines have been given by Williams.[3]

As early as 1917, Adams and Joy[4] had noted that the velocity displacements of hydrogen differed systematically from those of other lines although at that time the emission characteristics of the star were apparently not detected. A study of spectrograms taken at Victoria in 1937 confirmed the peculiar behaviour of the hydrogen lines and indicated the presence of weak emission on the redward edge of Hβ. Subsequent observations in the visible region revealed that Hα was an emission line of moderate intensity with a relatively weak absorption border on its violet edge. In addition to Hα the line λ5876 of HeI was also found to be an emission line of P Cygni type, only in this case the absorption component was stronger than the emission.

Numerical data on the velocity displacements and equivalent widths of lines in the spectrum of H.D. 190603 have been derived by the writer from 9 plates secured during the period 1937-1945, 6 in the ordinary region and 3 in the visible. Radial velocity measures of these plates have shown that not only hydrogen, but some of the helium lines as well, show displacements differing systematically from other lines. The weighted mean value of the stellar velocity derived from lines other than hydrogen and helium (mainly NII, OII, SiIII and SiIV) is +24.7 km./sec. This value, derived by the writer from 6 plates secured in the period 1937-1945, is in good agreement with an earlier series of spectra secured at this observatory in the period 1918-1920. Unpublished measures of this series by Boothroyd indi-

*Contributions from the Dominion Astrophysical Observatory, No. 1.

[1] *Ap. J.*, vol. 78, p. 389, 1933. [2] *P. Dom. Ap. O.*, vol. 5, p. 149, 1930.
[3] *Ap. J.*, vol. 83, p. 279, 1936. [4] *P. A. S. P.*, vol. 29, p. 259, 1917.

cate a mean value of the stellar velocity for lines other than hydrogen and helium of +25.6 km./sec. Since this value was derived from 19 plates and since it agrees within a kilometer with the later value, it is reasonable to assume that the stellar velocity is close to +25 km./sec. Earlier published values are almost certainly influenced by inclusion of the hydrogen and helium lines.

It is interesting to compare this value with the velocity displacements of individual lines in the various series of hydrogen and helium. This is done in Tables I and II which give not only the velocity displacements of emission and absorption lines but also the equivalent widths from Victoria spectrograms expressed in km./sec.

TABLE I. HYDROGEN

λ		Velocity		E. W. (km./sec.)	
		Abs.	Em.	Abs.	Em.
6563	Hα	− 131.3 (3)	+ 58.0 (3)	24 (2)	224 (2)
4861	Hβ	− 76.3 (7)	+ 84.8 (7)	41 (4)	13 (4)
4340	Hγ	− 4.4 (4)	..	60 (4)	..
4101	Hδ	+ 1.4 (4)	..	69 (4)	..
3970	Hε	+ 5.0 (6)	..	82 (1)	..

TABLE II. HELIUM

(*a*) $^3P^\circ - m^3D$ Series					(*b*) $2^1P^\circ - m^1D$ Series*		
	Velocity		E.W. (km./sec.)				
λ	Abs.	Em.	Abs.	Em.	λ	Velocity	E.W. (km./sec.)
5876	− 25.3 (2)	+ 104.7 (2)	37 (3)	14 (3)	6678	− 4.5 (2)	31 (1)
4471	+ 7.1 (6)	..	39 (2)	..	4921	+ 19.3 (6)	46 (4)
4026	+ 18.1 (6)	..	44 (2)	..	4387	+ 13.5 (6)	27 (2)
					4144	+ 25.8 (6)	25 (2)
					4009	+ 26.4 (4)	25 (2)

(*c*) $2^1S - m^1P^\circ$*

λ	Velocity	E.W. (km./sec.)
5016	− 34.5 (2)	16
3964	+ 30.3 (1)	21

*No emission observed for this series.

The figures in brackets indicate the number of spectra from which each measure is derived.

Table I shows clearly the P Cygni character of Hα and Hβ and further indicates that the later members of the Balmer series, Hγ, Hδ and Hε are considerably displaced to the violet, relative to the

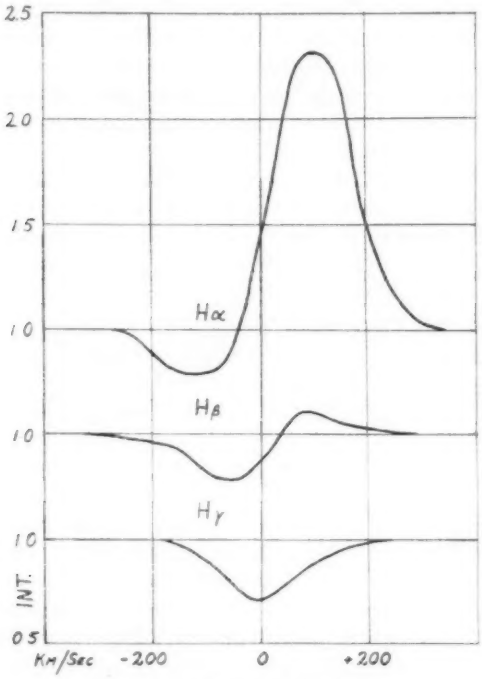

Fig. 1.—Profiles of Balmer lines, in H.D. 190603

stellar velocity. The well-known diffuse triplet series of helium (2^3P°–m^3D) shows a similar effect with λ5875 appearing in emission and a progression in the velocities of succeeding lines which suggests that higher members of the series would be close to the stellar velocity. In the case of the diffuse singlet series 2^1P°–m^1D the line λ6678 may have a slight shading of emission on its long wave-length

edge, but it appears mainly in absorption. Its velocity, however, is nearly 30 km./sec. more negative than the assumed stellar value, while the higher members of the series are close to the stellar motion. A similar effect is shown by the two lines of the 2^1S–m^1P° series although the measures are of lower weight. The velocity and inten-

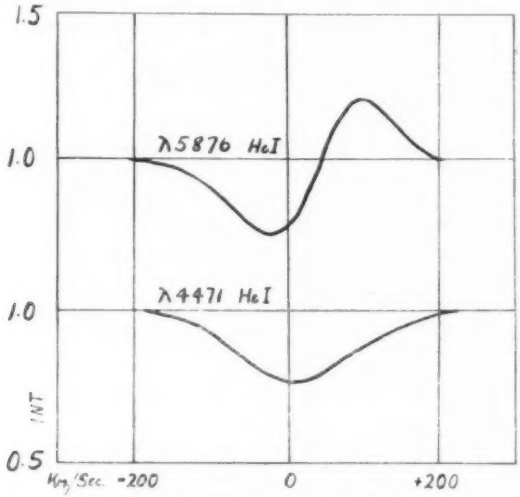

Fig. 2. — Profiles of the Helium lines, in H.D. 190603

sity relationships between successive series lines are further illustrated in figures 1 and 2, where profiles of a number of the hydrogen and helium lines are illustrated.

From what is known of the character of P Cygni emission in other stars, it seems reasonable to suppose that each of the hydrogen and helium lines may be explained as a blend of three components: (1) An absorption line in its normal position due to the reversing layer of the star; (2) An emission line arising in an outer shell with a width which is governed by the outward motion of atoms in the shell; (3) An absorption line which arises in an outer shell and which is displaced to the violet due to the outward motion of atoms composing the shell. In the case of the hydrogen and helium series the

earlier members which show evidence of emission are presumably largely influenced by (2) and (3). The later members of the series on the other hand are probably mainly due to (1). The interesting relationships between velocity, series number, and equivalent width can all be satisfactorily accounted for on the basis of various combinations of the three components.

Although only H and HeI have been observed in emission it is quite possible that the positions and intensities of other lines are affected by the physical process responsible for the star's P Cygni characteristics. There appears, however, to be no clear indication of differential velocity effects among atoms other than H and He. Further, the fact that the velocities of later members of the helium series approach the assumed stellar motion would suggest that line shifts due to the presence of an expanding shell are not of major importance for atoms other than H and He.

The radial velocity of interstellar calcium in the spectrum of H.D. 190603 is -12.2 and that of sodium is -7.2, weighted mean -10.5 km./sec. The equivalent width of CaII *K* is 36 km./sec. This leads to a distance of 1150 parsecs and an absolute magnitude corrected for space absorption of -4.6.

Dominion Astrophysical Observatory,
Victoria, B.C.
November 5, 1945.

OUT OF OLD BOOKS

By Helen Sawyer Hogg

> For out of olde feldes, as men seith,
> Cometh al this newe corn froe yeer to yere;
> And out of olde bokes, in good feith,
> Cometh al this newe science that men lere.
>
> Chaucer, *The Parlement of Foules.*

As the middle of the twentieth century draws near it would appear that many interesting observations and events of an astronomical nature have dropped out of the enormous background of astronomical knowledge of the present day. Only the oldest inhabitants remember them and most of us have only a hazy idea of them from condensed sentences in textbooks or current articles. With the destruction of European libraries during the war, much of this information will be lacking now in many of the great libraries. In view of these facts, it is our intention to publish from time to time extracts from old books and periodicals which may be profitable, and we hope, interesting reading for the Journal subscribers.

Krakatoa Eruption of 1883

The building up of the recent volcano Paricutin in Mexico, and the even more recent volcanic island rising off the coast of Japan the past month bring to mind the gigantic explosion of Krakatoa, with its effects on the atmospheric conditions the whole earth over.

The eruption was one of the most stupendous ever recorded. Krakatoa was an island between Java and Sumatra which had been built up in an old volcanic cone. The eruption occurred from August 26th to 28th, 1883. The large part of the volcanic island was blown sky-high. Where once an island rising 1,400 feet above sea level stood, a gaping hole was left in the sea floor, 1,000 feet deep in spots. The tonnage of material displaced in this violent manner is impossible to estimate. The column of stones, dust and ashes was hurled to a height of 17 miles or more in the atmosphere. The most serious effect of the eruption was the ocean waves, which reached a maximum of

fifty feet in height, and caused the death of more than 36,000 human beings. The ocean wave was recorded as far as the English Channel, 11,000 miles away. The actual sounds of the volcanic explosions were heard as far away as 3,000 miles.

The heavier stones came down on the surrounding islands, to a depth sufficient to bury the forests! But the smaller ash particles were carried into the upper levels of the atmosphere and took many months to settle out. They were responsible for most extraordinary atmospheric conditions the world over. In the early fall of 1883 the reports of amazing sky conditions betray much bewilderment, but by the spring and summer of 1884 the scientific world in general held Krakatoa as responsible. A century earlier Benjamin Franklin had pointed out that the severe winter of 1783-84 might have been caused by the vast quantities of smoke hurled into the earth's atmosphere by volcanic action at Hecla, in Iceland.

The scientific periodicals of the year 1883 and 1884 contain literally dozens of eye-witness descriptions of the spectacular skies as seen from a variety of spots on the earth's surface. A few of the more interesting and significant will be quoted.

From *Knowledge*, January 4, 1884, p. 15.

Red Skies in America

I am glad to see the article upon "Extraordinary Sunsets" in the last number of *Knowledge* just received. It sems strange to me, however, that no accounts of the phenomenon have yet reached you from this side; but I suppose you will have plenty of them in due time. My attention was first called to the matter about the latter part of November—somewhere about the 20th, I think. I was in the office, when one of the clerks came in and said that there "was a tremendous fire somewhere up town." I at once went out, and saw the whole western heavens illuminated. The sight was such a strange one that we went on top of the building, and it was at once evident that it was no fire. As near as I can recollect the "red glare" extended for upwards of 40° from the horizon, and for 60° or so along it. All the large buildings, steeples, etc., of the city stood out clear and distinct upon the bright background of the sky, as if lit up by some immense conflagration. This was about six o'clock in the evening. A little before seven o'clock the phenomenon had pretty well disappeared. People in the streets were watching it, and wondering what was the matter in the sky.

One old "darkie" whom I first asked upon coming out of the office where the fire was, answered: "Dat's no fire, mister, dat's de elements; de world must

be coming to an end." The general impression among the masses seemed to be that something was wrong in the sky.

I have not much of an eye for colour, but to me it appeared fiery red, without any green whatever. The next day I saw in the papers that one of the fire departments in a Northern city had been called out by mistake, having taken this "red glare" to be an immense fire.

This strange light has been hanging around the sun, more or less, ever since, although to me the phenomenon has never been as marked as upon that occasion.

W. H. NUMSEN

Baltimore, U.S.

A report of special interest to Canadian readers comes from Halifax, and is in *Knowledge*, February 8, 1884, p. 90.

AFTER-GLOW IN AMERICA

- - I beg to inform you that on three successive evenings towards the close of November—I forget the exact dates—the after-glow at this place was very remarkable. I did not notice anything extraordinary at the time of sunset, which was a little after half-past four, but from about half-past five to quarter past six the whole western sky was lit up by a very vivid crimson light, rising very nearly to the zenith.

- - I have observed no discolouration of the sun either at sunrise or sunset, and I believe no such effect has been observed in these parts.

On the morning of Dec. 18 I happened to be up at quarter-past six. Looking out of an east window I saw all the effects of sunrise over the south-eastern horizon. The colour was amber shading into orange, and the clouds were tipped with an orange red. At a few minutes before seven I left my house, and saw the spires of the churches and the roofs of the higher houses gilded so strongly with sunlight that I fancied my watch must have deceived me and turned round to the eastward several times to see if the sun had actually risen.

From seven to half-past seven, or a little later, I was in a building. Coming out I looked to the east again, and saw the ordinary effects of a rather dull sunrise. The sun actually rose a few minutes later.

Last night again (26th) there was a remarkable after-glow, lasting from about quarter-past five to near six. It was at its brightest at about half-past five, and was of an orange-red colour, different to the crimson in November.

CHAS. S. AKERS, COL. R.E.

Halifax, Nova Scotia, Dec. 27

From *Nature*, November 22, 1883, p. 87.

SOFT SUNLIGHT

In a letter from Maranhoa, Brazil, the writer states that from August 31 up to September 6, the sun until 7 a.m. could be looked at without the least difficulty, its light being as soft and pale as the moon's.

From *Knowledge*, February 1, 1884, p. 77.

BLUE MOON

There is a very old Norfolk proverbial saying, once in a blue moon. Can it have had its origin in the actual and yet very infrequent observation of that phenomenon? Or is it a mere random shot at an illustration of rare events?

The moon here in November was of the intensest sapphire blue, the perfectly clear sky looking rather slaty. This morning at 6.30 there was a fine sky-glow, and so last week. It certainly appeared to come from aqueous vapour.

Jan. 22, 1884 CENTRE-NORFOLK

And a delightful bit of scientific humour from *Knowledge*, March 14, 1884, p. 166.

The red after-glow that has caused so much discussion among philosophers is now explained by a correspondent of the *Scientific American*, who asserts that the phenomenon is due to the red spot from the planet Jupiter. This great rosy cloud disappeared several months ago from the atmosphere of Jupiter, has had just time, according to this correspondent, to travel to our earth, and is now hovering over us, causing the ruby colouring of our skies night and morning. Nobody ever has or will be able to prove that this is not the fact; therefore, it must be true, says the correspondent. The question is settled: it is useless to talk further about cosmic dust, Java ashes, or aqueous vapour.

The various observations of colours are summed up briefly as follows by F.A.A.R. in *Nature*, June 12, 1884, p. 155.

The matter projected into the upper atmosphere appears to have passed around the globe westwards with great velocity, and to have diffused itself towards north and south much less rapidly. A stratum of fine dust thus formed itself at an elevation probably exceeding the altitude of the known upper currents. This stratum caused the sun to look green or blue on the Gold Coast, in the West Indies, at the Sandwich Islands, in India and the Indian Ocean, and last, as late as September 24, in the Soudan, nearly a month after the eruption of Krakotoa. The moon and stars were frequently greenish in Europe in December and January, up to four months and a half after the eruption, and the sun whiter than usual towards setting. The finely divided matter which thus deprived the sun and moon of part of the rays which go to form the compound white, was plainly of a different grain from the small particles commonly present in the sky.

Next month we shall consider some curious telescopic observations of this phenomenon.

NOTES AND QUERIES

Communications are invited, especially from amateurs. The Editor will try to secure answers to queries.

Optical Supplies for Canadian Observers

Amateur and professional astronomers in Canada will be intrested in a circular recently issued by the Clifford and Edwards Co., 213 Broadway Ave., Toronto. This firm has acquired a large stock of achromatic doublets, single lenses and various types of prisms. These are war surplus and reject stock manufactured by a leading Canadian optical firm. Almost a hundred items are listed. Prices are given for uncentred and centred lenses, for slightly chipped but completely serviceable prisms, and for unchipped perfect prisms.

Any of this material we have so far seen has been of fine quality. Amateurs wishing to make up highly corrected and achromatised eyepieces, monocular or binocular field glasses or small telescopes will be pleased to note the wide selection of high grade optical components available at reasonable prices. A complete list of the prisms and lenses may be obtained by writing to the above firm.

F. S. H.

A New Feature in the Journal

This month the Journal starts a new section, pages 161-164, entitled "Out of Old Books." During recent years Dr. Helen Sawyer Hogg has made very intensive bibliographical searches in connection with her studies of globular clusters, variable stars, and novae. In the course of these she has been impressed with the large number of interesting and valuable old articles which are becoming relatively inaccessible. In order to call some of these to the attention of newer astronomers, she now plans to publish selected excerpts from such articles from month to month in this Journal.

F. S. H.

Wise Words for Astronomers—and Others

All will agree that at present there is much confusion in our ideas on education. For half a century and more the validity of everything

intellectual has been questioned and the two great wars have shaken our social organizations to their very foundations. The word 'culture' is hard to define and yet we recognize it without difficulty. It is surely a mark of an educated person. In a recent address Dr. Sidney Smith, the new president of the University of Toronto, insisted that the Arts Course, with its training in the humanities and the social sciences, is the very core of our system of higher education. He likened it to the hub of a wheel of which the professional courses are the spokes. If the hub is not well and strongly built the whole carriage or machine will in a few years fail. In former times the importance of classical studies may have been over-emphasized but they should not be overlooked.

Perhaps the following quotations from Thoreau's always stimulating *Walden* (1854) may be read with interest:

> It is worth the expense of youthful days and costly hours, if you learn only some words of an ancient language, which are raised out of the trivialness of the street, to be perpetual suggestions and provocations. It is not in vain that the farmer remembers and repeats the few Latin words which he has heard. Men sometimes speak as if the study of the classics would at length make way for more modern and practical studies; but the adventurous student will always study classics, in whatever language they may be written, and however ancient they may be. For what are the classics but the noblest recorded thoughts of man?
>
> However much we may admire the orator's occasional bursts of eloquence, the noblest written words are commonly as far behind or above the fleeting spoken language as the firmament with its stars is behind the clouds. *There* are the stars, and they who can may read them. The astronomers forever comment on and observe them. They are not exhalations like our daily colloquies and vaporous breath. What is called eloquence in the forum is commonly found to be rhetoric, in the study. The orator yields to the inspiration of a transient occasion, and speaks to the mob before him, to those who can *hear* him; but the writer, whose more equable life is his occasion, and who would be distracted by the event and the crowd which inspire the orator, speaks to the intellect and heart of mankind, to all in any age who can *understand* him.
>
> A written word is the choicest of relics. It is something at once more intimate with us and more universal than any other work of art. It is the work of art nearest to life itself. It may be translated into every language, and not only be read but actually breathed from all human lips;—not be represented on canvas or in marble only, but be carved out of the breath of life itself. The symbol of an ancient man's thought becomes a modern man's speech.

C. A. C.

A Brilliant Meteor In 1668

It is interesting to find in one's reading that certain things were seen and done three centuries ago much as they are now. In the entry in Pepys' *Diary* for Thursday, May 21, 1668, there is a reference to a bright meteor which is worth quoting:

All the morning at the office, and at noon my clerks dined with me, and there do hear from them how all the town is full of the talk of a meteor, or some fire, that did on Saturday last fly over the City at night, which do put me in mind that, being then walking in the dark an hour or more myself in the garden, after I had done writing, I did see a light before me come from behind me, which made me turn back my head; and I did see a sudden fire or light running in the sky, as it were towards Cheapside ward, and it vanished very quick, which did make me bethink myself what holyday it was, and took it for some rocket, though it was much brighter than any rocket, and so thought no more of it, but it seems Mr. Hater and Gibson going home that night did meet with many clusters of people talking of it, and many people of the towns about the city did see it, and the world do make much discourse of it, their apprehensions being mighty full of the rest of the City to be burned, and the Papists to cut our throats. Which God prevent!

There are other matters entered in the *Diary* for 1668 which show that life then had its lights and shadows of a pattern quite familiar to us in this our modern atomic age:

June 17. *His poor wife.* By and by home, and there with my people to supper, all in pretty good humour, though I find my wife hath something in her gizzard, that only waits an opportunity of being provoked to bring up; but I will not, for my content-sake, give it. So to bed, glad to find all so well here, and slept well.

July 14. *People not in power.* This afternoon my Lady Pickering come to see us; I busy, saw her not. But how natural it is for us to slight people out of power, and for people out of power to stoop to see those that while in power they contemned!

August 31. *Repairs while you wait.* And so to Hercules Pillars, and there dined all alone, while I sent my shoe to have the heel fastened at Wotton's, and thence to White Hall to the Treasury chamber, where did a little business, and thence to the Duke of York's playhouse and there ..... saw "Hamlet".

December 3. *His first coach; 'twas ever thus!* We sat under the boxes, and saw the fine ladies; among others, my Lady Kerneguy, who is most devilishly painted. And so home it being mighty pleasure to go alone with my poor wife, in a coach of our own, to a play, and makes us appear mighty great, I think, in the world; at least greater than ever I could or my friends for me, have once expected; or, I think, than ever any of my family ever yet lived, in my memory, but my cozen Pepys in Salisbury Court. So to the office, and thence home to supper and to bed.

C. A. C.

MEETINGS OF THE SOCIETY

AT VICTORIA

January 10, 1945.—The meeting was called to order at 8.15 p.m. by the President, Dr. K. O. Wright. The minutes of the previous meeting were read and adopted. Mr. W. H. Stilwell gave a brief report of current phenomena.

The speaker of the evening, Dr. H. D. Smith, of the Physics Department, University of British Columbia, chose as his subject "The Time Scale of the Universe." He described the methods of determining the age of the earth's crust from the products of disintegration of radio active elements. This amounts to approximately 2 billion years. Then we must add a few million for the length of time for the earth's crust to be formed from a gaseous state. The sun itself is billions of years old. Sir James Jeans' theory of the formation of the stars from the time when all of space was filled with a rare primordial gas was described. Due to gravitational attraction the molecules formed clouds of gas and stars. Gamow extended this theory to show how the stars themselves combined to form galaxies. From a study of the present velocities of the stars in our galaxy its age is estimated to be less than 10 billion years. Dr. Smith concluded with an explanation of the expanding universe which is finite yet unbounded and where most distant galaxies are receding faster than the nearer ones. He said that the temperature of our sun would increase greatly before its death so the future was bright and also hot.

After some interesting questions Dr. John Stevenson extended the thanks of the audience to Dr. Smith for his very entertaining and enlightening talk.

February 14, 1945.—Dr. K. O. Wright, President, opened the meeting. The names of six new members were read. Several amateur members contributed to the programme: Terry Scaife gave a short talk on the telescope; Mr. Hobday described the process whereby several telescopic mirrors made by members of the society were aluminized at the Dominion Astrophysical Observatory under the guidance of Dr. Wright, and the mirrors were displayed.

Mrs. J. Noble spoke on the motions of the stars. The so-called fixed stars are really moving in proper motion and radial velocity. Boss has illustrated the relation between proper motion and spectral class. Mrs. Noble described how some stars move as a group or cluster and also there is a general preference for two directions of motion. One explanation of this streaming is on the basis of galactic rotation.

Mr. R. S. Jervis-Read continued the symposium by talking of the motion of the sun towards the solar apex, near Vega. He showed by diagrams the method of deriving the right ascension and declination of the solar apex and also the sun's velocity.

Lt. Cmdr. Scaife gave a vote of thanks to the speakers for their informative and interesting talks. The members contributed enough in a collection to pay the balance on the observatory and telescope purchased from Mr. Brydon.

March 14, 1945.—The meeting was called to order at 8 p.m. by the President, Dr. K. O. Wright. Miss Langworthy spoke briefly of the work of the library of the Society. Dr. Wright described the path of the eclipse of the sun to occur July 9, 1945.

Mr. W. H. Stilwell of the Dominion Astrophysical Observatory was the main speaker of the evening. His topic was "Surveying Canada's Northland." The first part of the lecture consisted of an explanation of Ball's Constant Altitude method of obtaining longitude and latitude from the stars. The instrument, the Wild Transit, is set for a constant altitude and the exact sidereal times at which stars cross this altitude mark at given azimuths is noted. From this information and the altitude of the north pole the observer's latitude and longitude are computed by a graphical solution. The second half of the lecture consisted of slides showing aerial and ground photographs of the Ungava and James Bay regions depicting the nature of the country and the life of the Indians and Eskimos inhabiting those regions.

Mr. Trueman expressed the appreciation of the audience to the speaker.

April 11, 1945.—Dr. K. O. Wright called the meeting to order at 8 p.m. One new member was elected. Mr. Peters gave a brief talk on current phenomena describing the nine brightest stars in the sky at present and the two planets, Jupiter and Saturn. It was announced that the final payment had been made on the Brydon telescope, and the president again gave an announcement concerning the observing sections in the society and also announced that the programme "Summer Evenings with the Stars" would again be given. Mr. Hobday read a letter from the Scientific Instruments Laboratory in Vancouver which stated that they had a good supply of lenses and prisms for the telescope makers.

Mr. G. Cave Brown Cave, Chief analyst of the Department of Mines, B.C. spoke on "Photography and the Stars." He treated the subject from a theoretical and scientific standpoint. First he described the photographic negative which is an emulsion of gelatin and crystals of silver bromide. He described the factors determining the characteristics of the emulsion such as diameter of the grains, number of grains per cc. and explained why gelatin is the best material to use. When light impinges on silver sulphide specks which are on the crystals of silver bromide a latent image is formed which consists of specks of metallic silver. This metallic silver is formed when the silver sulphide specks take up electrons and the silver ions which are present as a gas thus move to them. Mr. Cave Brown Cave then described the developing process which is a matter of continuing the reduction of those silver bromide crystals which have already latent image specks of metallic silver on them. He also ex-

plained many of the researches which have been carried out to determine the relation between density and exposure, gamma which indicates the contrast of the film and is the tangent of the straight line portion of the characteristic or H. and D. curve. For a given film this increases with increasing development. The resolving power is influenced by the turbidity effect, contraction of the gelatin and the repulsion of neighbouring images.

Mr. Shaw spoke briefly thanking the speaker for his very instructive lecture.

E. C. STILWELL, *Recorder.*

October 10, 1945.—Dr. K. O. Wright called the meeting to order at 8 p.m., extending a welcome on behalf of the Society to Dr. R. M. Petrie on return from duty with R.C.N.V.R. Minutes of the meeting held on April 11th were read and adopted.

Mr. R. Peters gave a brief enumeration and description of the more readily visible planets for the coming month, mentioning the Ring Nebula in the Constellation Lyra as being of special interest and explained the formula by which the diameter of such objects are obtained.

The President outlined the arrangements made for the observing meetings, with the Brydon telscope, and introduced the speaker of the evening Lieut. Commander C. A. MacDonald, R.C.N.R. In the course of his instructive lecture on "Winds and Ocean Currents" Lieut. Commander MacDonald explained the fundamental laws governing the formation and movements of cyclones and anti-cyclones in the northern and southern latitudes, respectively, monsoons in the Indian Ocean and typhoons in and adjacent to the China Seas and showed how, by knowledge of their characteristics, seamen could use them to great advantage in navigation, and also in the event of a storm approaching, avoid being subjected to the potential danger of its vortex. In addition to information on temperature, height and speed of winds and currents, Lieut. Cmdr. MacDonald described those of particular interest, in various localities throughout the world. Dr. Petrie returned a vote of thanks to the speaker on behalf of those present.

November 14, 1945.—Dr. K. O. Wright called the meeting to order at 8.15 p.m. Minutes of the meeting held on October 10 were read and adopted. Six new members were accepted into the Society. Mr. Hobday gave a brief résumé of the outstanding phenomena to be observed during the coming month.

The President introduced Dr. Crooker of the University of British Columbia, speaker for the evening. During the course of his lecture on "Military Telescopes", Dr. Crooker outlined the special requirements of optical glass for military use, the process of its manufacture and the plant set up by Research Enterprises to produce the glass. In spite of the fact that optical glass had not been made in Canada prior to Research Enterprises commencing operations in 1941 and the consequent lack of facilities, mass production of optical glass, surpassing the exacting requirements of military use was achieved. Dr. Beals

rendered a vote of thanks to the speaker on behalf of those present. The President drew the attention of members to the annual meeting and dinner to be held on 14th December at the Y.W.C.A. The meeting adjourned at 10.15 p.m.

December 14, 1945.—The meeting was held in conjunction with a dinner and was called to order at 6:40 p.m. Eighty-five members including relatives and friends were present. A toast to the King was proposed by the President. Silent tribute was paid to four members who passed on during the year, Mrs. Pearce, Mrs. Blaylock, Mrs. Hailstone and Mrs. Langworthy. Secretary and Treasurer's reports were read by Miss McDonald, the librarian's report by Miss Langworthy and President's report by Dr. K. O. Wright.

Minutes of the last annual meeting were read by Lieutenant Commander A. M. P. Scaife in absence of Recorder Mrs. E. C. Stilwell, and adopted. The annual selection of officers was carried out and results reported by the scrutineer the Commander Tingley.

A musical programme consisting of piano solos by Mrs. Beals and vocal solos by Mrs. Simpson were enjoyed by all.

Mr. R. Peters extended the appreciation of the Society to the press for their co-operation during the year. Mr. Shaw thanked the musicians for their contributions to the evening's entertainment.

The speaker of the evening Dr. C. S. Beals of the Dominion Astrophysical Observatory was introduced by the President. During the course of his lecture entitled "Practical and Commercial Value of Astronomy" Dr. Beals referred to the contributions that have been made to science by astronomers, past and present, particularly in the realm of physics by giving specific instances. He showed how the knowledge gained by their research has been put to every day uses. Dr. McKellar thanked the speaker on behalf of those present for his informative and ably delivered lecture.

A. M. P. Scaife, for *Recorder.*

AT WINDSOR

January 8, 1946.—The Windsor Centre met at 8 p.m.; the new president, Mr. C. B. Hallam, in the chair. The regular meeting place, the Art Gallery of the Willistead Library, was well filled; some fifty-five members and friends registering. Several members of the Detroit Astronomical Society were welcomed.

The regular feature, "Astronomical Events of the Month", was presented by the new treasurer, Mr. C. A. Bell. This portion of the programme is useful in aiding the observations of amateur astronomers. In addition to information regarding planets and constellations, Mr. Bell also spoke about sunspots, times of sunrise and new uses of radar.

The Past-President, C. H. Montrose introduced the chief speaker, Mr. L. F. McGee, B.A., head of the science department at the W. D. Lowe Vocational

School, Windsor. Entitling his lecture, "Atomic Energy", Mr. McGee reviewed the historical background of the atom. He mentioned the contributions of Dalton, Einstein, Jeans and Rutherford. With the establishment of the nuclear theory of atomic structure, Dalton's idea of the indivisible atom broke down.

Experiments, wherein the nuclei of many elements were bombarded with neutrons, followed. The elements with the heaviest nuclei tended by nature to be unstable and it followed that careful studies were made on the effect of neutron bombardment of the heavy element, uranium.

In January, 1939, Dr. Otto Hahn announced that this bombardment produced an isotope of barium. Dr. Lise Meitner saw the importance of this and discussed it with Dr. Nils Bohr. Soon Dr. Bohr arrived in America and leading scientists confirmed Dr. Hahn's observations.

With the help of excellent drawings, Mr. McGee outlined the theory of fission reactions. Briefly referring to the atomic bomb, Mr. McGee said that atomic energy will not destroy the world. Science will continue to seek truth through scientific experiments. Scientists do not cringe in fear of atomic energy and will not attempt to hide the results of their experiments. Mr. McGee concluded with the thought that to attempt to hide the truth is to return to barbarism.

A hearty vote of thanks moved by councillor E. B. Krebser was accorded Mr. McGee.

Councillor F. W. C. Jones introduced two visitors from Michigan, Mr. W. F. Voglesong of Trenton, and Mr. R. T. Graham of Wyandotte, who related their experiences in the manufacture of uranium and plutonium at the Clinton Engineer Works, Oakridge, Tenn., and the Handford Engineer Works in Washington. Both cheerfully answered questions and led a discussion on the probable effects of the atomic bomb.

After thanking the speakers and announcing the February 12th meeting, the president declared the meeting adjourned.

RUSSELL WARWICK, *Secretary.*

The Royal Astronomical Society of Canada

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